Vibration measurements at the A0 laser room

Rodion Tikhoplav

14th February 2005

Output stability (both energy and pointing) is a crucial parameter for a laser system performance. It is especially important for the A0 photocathode drive laser, since firstly, it is a very complex system (oscillator and two stages of amplification). Secondly, one of the amplification stages, the multipass, is not driven into saturation (like a re-gen), thus it amplifies the fluctuations as well. There are many sources of laser instability, e.g.: air currents, temperature fluctuations, electrical circuitry instabilities, vibrations. The latter is especially difficult to diagnose and improve; our attempt to do so is described in the current note.

The vibration measurements at the A0 laser room were performed on the floor and on three optical tables: Oscillator (Table One), Multipass (Table Two) and Compression (Table Three). The measurements were done for both vertical and horizontal modes using low frequency (0.05–200 Hz) velocimeters of type SM-3KV#1429 (horizontal) and SM-3KV#1434 (vertical). Refer to tables I and II for the results. A typical oscilloscope trace can be found in Fig. 1.

Table I
Vertical vibration, sensor # 1434

	17 Hz		30 Hz		40* Hz		60 Hz		Resonance frequency
	mV	nm	mV	nm	mV	nm	mV	nm	
Floor	30	3	30	2	90	4	30	1	N/A
Table One	30	3	30	2	320	13	100	3	38 Hz
Table Two	30	3	30	2	150	6	30	1	N/A
Table Three	20	2	20	1	220	10	120	4	45Hz

* Air compressor is ON

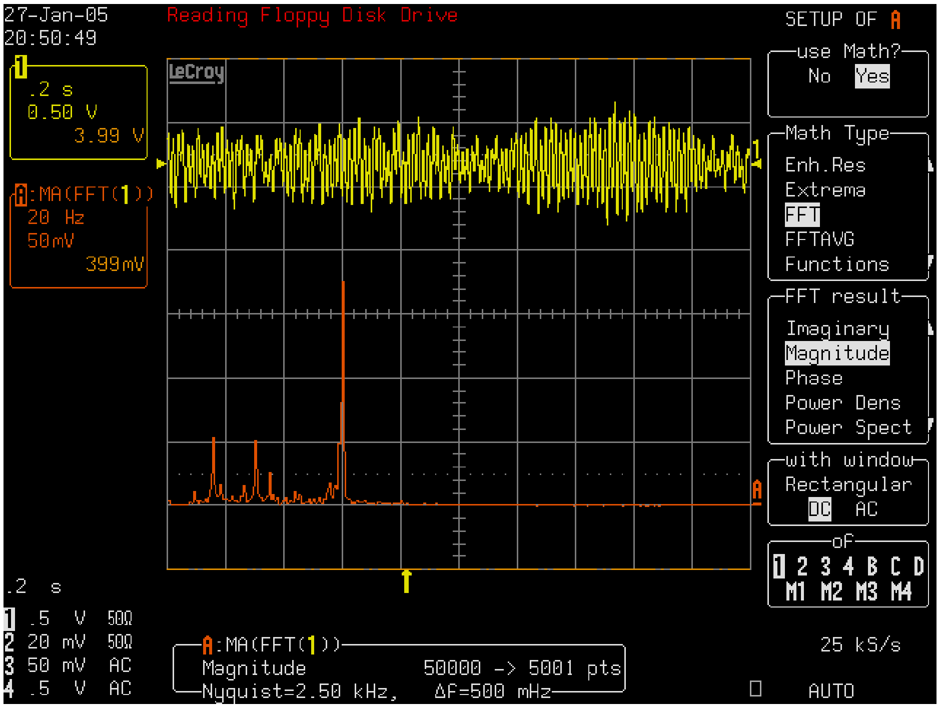

Figure 1: A typical Lecroy oscilloscope trace of a velocimeter in the laser room. The upper trace corresponds to the signal, the lower to its FFT

The Oscillator table has an air-floating capability which has been successfully utilized. Floating the tables helps reducing the noise level and shrinking the resonance range as well as shifting it to the lower frequency region. The latter corresponds to the movement of an optical table as a whole (thus the optical elements on the table do not move relative to each other) rather than exciting a wave on its surface. The results could be found in table III.

Table II
Horizontal vibration, sensor # 1429

	17 Hz		17* Hz		40* Hz		60 Hz		Resonance frequency
	mV	nm	mV	nm	mV	nm	mV	nm	
Floor	6	0.6	6	6	10	0.4	6	0.2	Low <1 Hz
Table One	70	7	680	66	100	4	–	–	15 Hz
Table Two	60	6	500	48	–	–	–	–	15 Hz
Table Three	80	8	590	57	30	1	10	0.3	15Hz

Table III
Oscillator Table (One) is floated

	1.8 Hz		5 Hz		5* Hz		12* Hz		Resonance frequency
	mV	nm	mV	nm	mV	nm	mV	nm	
Vertical	–	–	40	15	50	19	–	–	5 Hz
Horizontal	20	20	10	4	10	4	50	7	1.8, 2.5, 5 Hz

We have also used higher frequency seismometers (both velocimeter and accelerometer types). We have performed the measurements at Argonne National Lab (APS facility) as well. A0 facility is approximately three times noisier comparing to the APS (see Fig. 2).

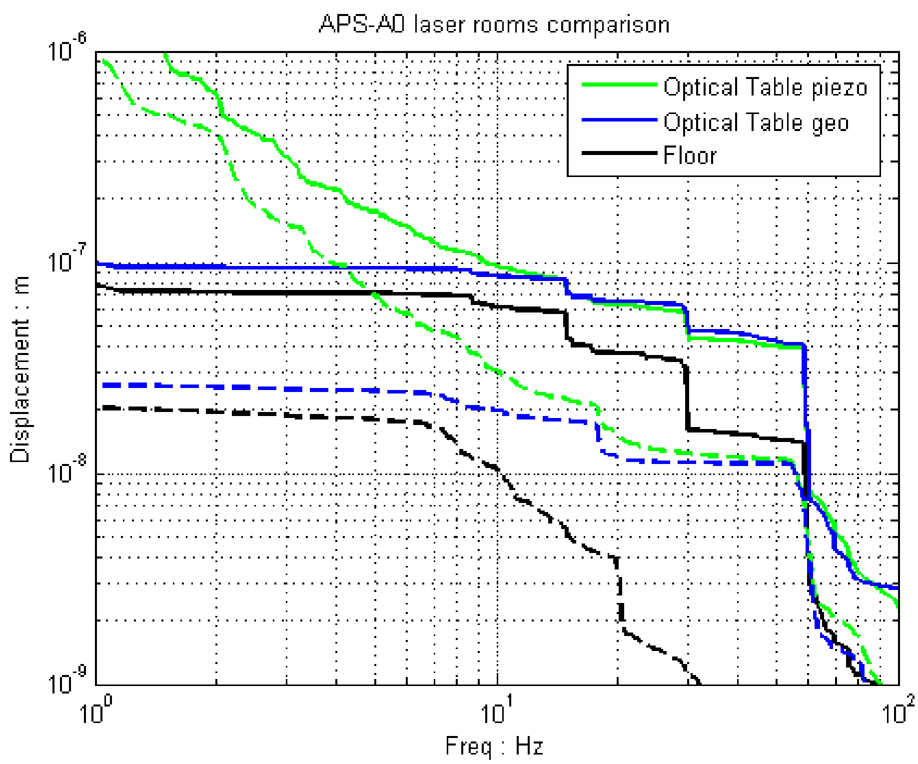

Figure 2: Integrated vibration measurements in the A0 (solid line) and APS (broken line) facilities. Integration goes from high to low frequency.

Conclusions

1. The table oscillations amplitude is higher than the floor's (as much as 10 times higher). This is a definite case of a resonance.
2. The horizontal vibrations occur at lower frequency comparing to the vertical (17 Hz vs. 40 Hz) and at higher magnitude (66 nm vs. 13 nm)
3. The overall integrated amplitude for the worst conditions is less than the wavelength (1μ), so to the first approximation we don't have to worry.
4. On the other hand, we should not completely neglect oscillations with a magnitude in the order of 100 nm either (since, e.g., it could be amplified due to the resonance in different optical parts—we are not that far from the wavelength after all), but rather try to decrease it as much as possible.
5. The single big source of the vibration is an air-compressor situated right behind the laser room wall. If we get rid of this source (by removing or isolating the compressor) we can reduce the noise level by as much as a factor of ten and be comfortably far away from the wavelength level (see tables I and II).
6. Although it helps reducing the noise level, floating the tables is not very practical. It becomes very sensitive to the operator in the laser room—simple touch of the table is enough to initiate the resonant oscillations.

Acknowledgement

My special thanks to Cristian Boffo for his help with measurements at APS and A0.